A taste of Supercomputer Reliability Research at Sandia

Red Storm Quarterly Review
Oct 25, 2007

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Scalable Systems Architecture (1422)

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
for the United States Department of Energy's National Nuclear Security Administration
under contract DE-AC04-94AL85000.

Reliability is hard!

System Facts:

- 124.42 teraOPS theoretical peak performance
- 12,960 compute nodes,
  320 + 320 service and I/O nodes
- 40 terabytes of DDR memory
- 340 terabytes of disk storage
- Linux/Catamount Operating Systems
- Approximately 3500 ft2 including disk systems
- <2.5 megawatts of power and cooling
- 3,710 Linux computers used to control this beast
- 14,240 high-speed network interfaces

Hmmm, which wire… is loose?

Mission Critical

+

Many points of failure

+

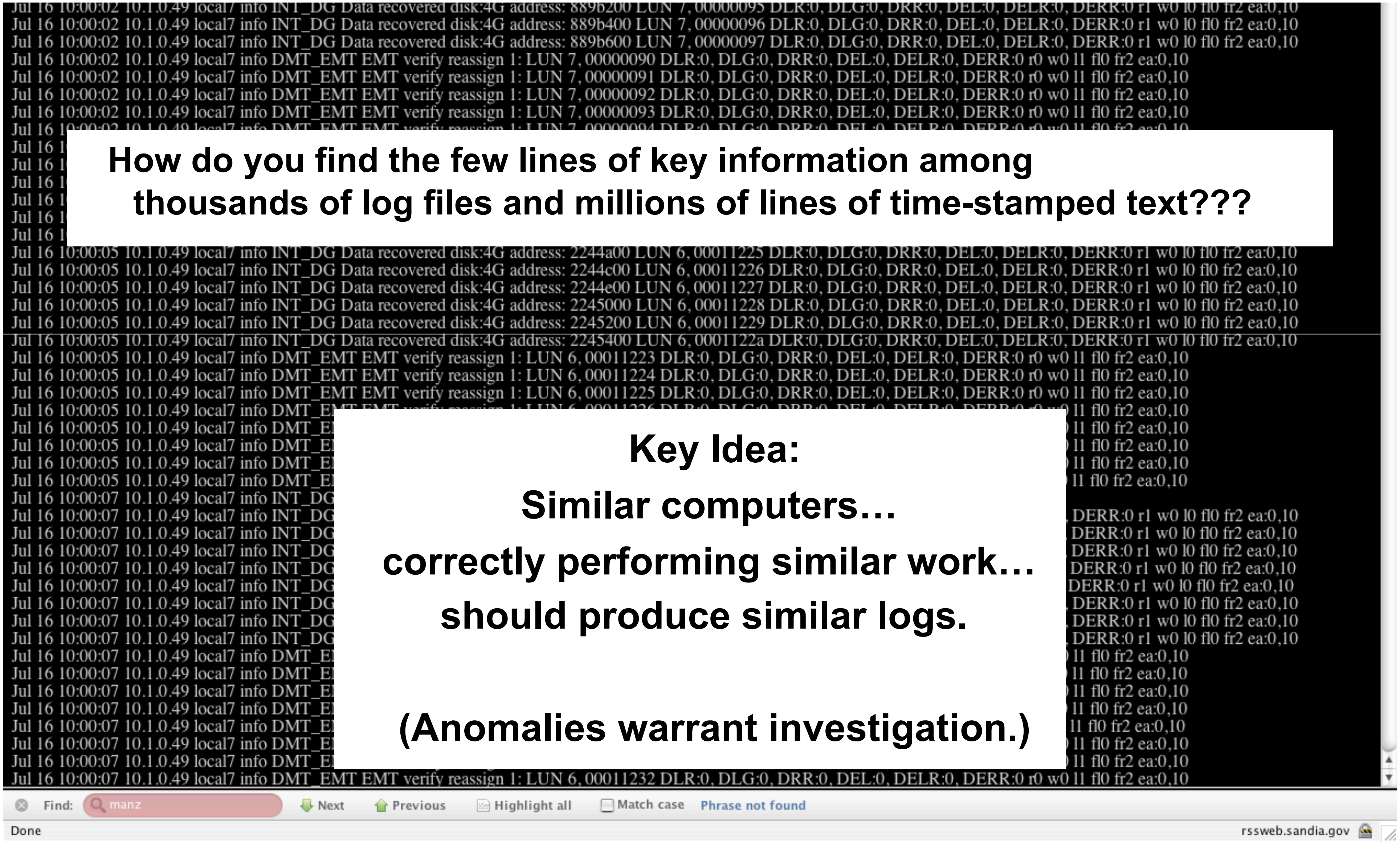
Complex and dynamic interdependencies

=

Rich research area!

System Logs

Are: Ubiquitous! Informational! Vast!



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Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889b200 LUN 7, 00000095 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889b400 LUN 7, 00000096 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889b600 LUN 7, 00000097 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 7, 00000090 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 7, 00000091 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 7, 00000092 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
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Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2244a00 LUN 6, 00011225 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2244c00 LUN 6, 00011226 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2244e00 LUN 6, 00011227 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245000 LUN 6, 00011228 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245200 LUN 6, 00011229 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245400 LUN 6, 0001122a DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011223 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011224 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011225 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_E                                                                    l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_E                                                                    l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_E                                                                    l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_E                                                                    l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_E                                                                    l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG                                                                   DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG                                                                   DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG                                                                   DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG                                                                   DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG                                                                   DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG                                                                   DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG                                                                   DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG                                                                   DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_E                                                                    l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_E                                                                    l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_E                                                                    l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_E                                                                    l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_E                                                                    l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_E                                                                    l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_E                                                                    l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011232 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
```

How do you find the few lines of key information among thousands of log files and millions of lines of time-stamped text???

Key Idea:

Similar computers…

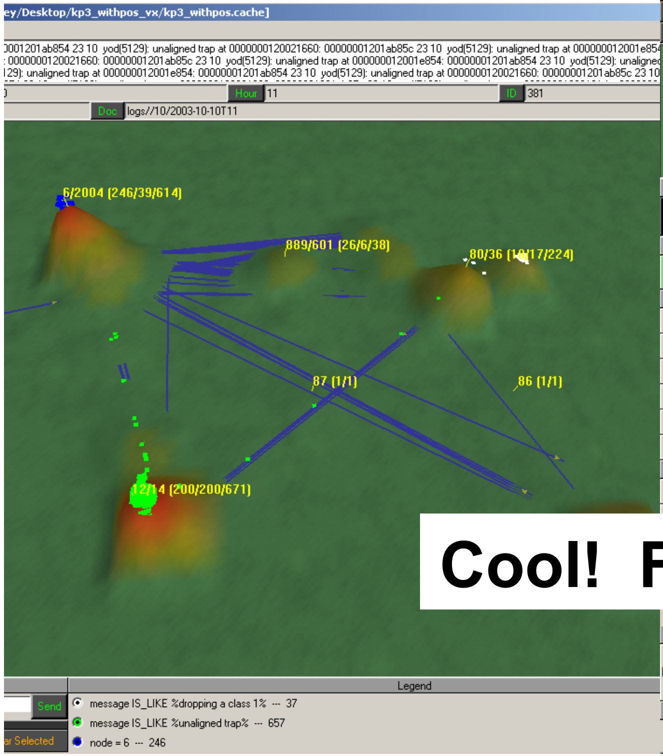
correctly performing similar work…

should produce similar logs.

(Anomalies warrant investigation.)

Latent Semantic Analysis

1. Calculate logfile-logfile similarities (via SVD)
2. Cluster (VxOrd)
3. Explore themes (VxInsight/Threatview)



ey/Desktop/kp3_withpos_vx/kp3_withpos.cache]

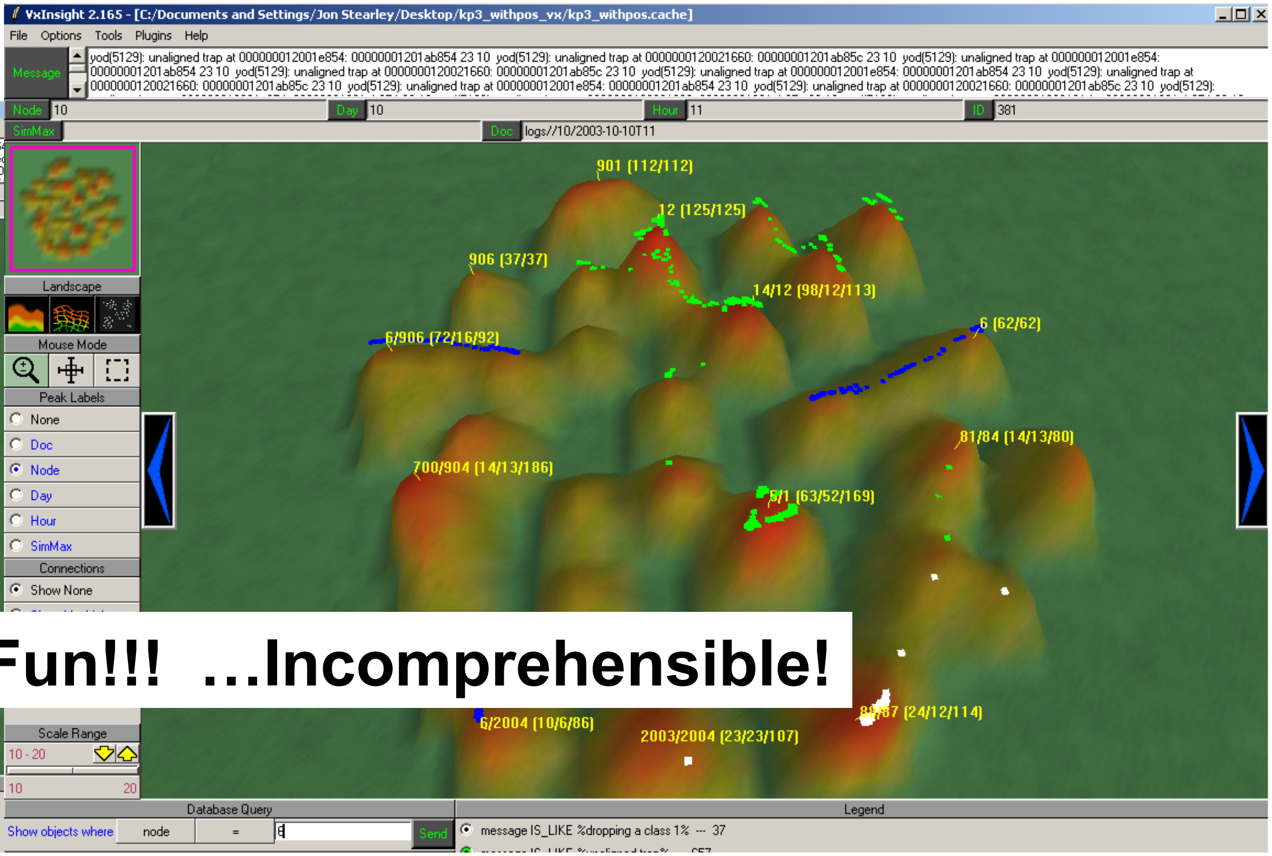
```
)001201ab854 23 10  yod(5129): unaligned trap at 000000012002166O: 00000001201ab85c 23 10  yod(5129): unaligned trap at 000000012001e854
: 000000012002166O: 00000001201ab85c 23 10  yod(5129): unaligned trap at 000000012001e854: 00000001201ab854 23 10  yod(5129): unaligned
129): unaligned trap at 000000012001e854: 00000001201ab854 23 10  yod(5129): unaligned trap at 000000012002166O: 00000001201ab85c 23 10
```

Hour 11 | ID 381

Doc logs//10/2003-10-10T11

Legend

- ○ message IS_LIKE %dropping a class 1% --- 37
- ● message IS_LIKE %unaligned trap% --- 657
- ● node = 6 --- 246



VxInsight 2.165 - [C:/Documents and Settings/Jon Stearley/Desktop/kp3_withpos_vx/kp3_withpos.cache]

Message:

```
yod(5129): unaligned trap at 000000012001e854: 00000001201ab854 23 10  yod(5129): unaligned trap at 000000012002166O: 00000001201ab85c 23 10  yod(5129): unaligned trap at 000000012001e854:
00000001201ab854 23 10  yod(5129): unaligned trap at 000000012002166O: 00000001201ab85c 23 10  yod(5129): unaligned trap at 000000012001e854: 00000001201ab854 23 10  yod(5129): unaligned trap at
000000012002166O: 00000001201ab85c 23 10  yod(5129): unaligned trap at 000000012001e854: 00000001201ab854 23 10  yod(5129): unaligned trap at 000000012002166O: 00000001201ab85c 23 10  yod(5129):
```

Node 10 | Day 10 | Hour 11 | ID 381

SimMax | Doc logs//10/2003-10-10T11

Peak Labels: ○ None ○ Doc ● Node ○ Day ○ Hour ○ SimMax

Connections: ● Show None

Scale Range: 10 - 20 (10 to 20)

Database Query: Show objects where node = 6 Send

Legend

- ○ message IS_LIKE %dropping a class 1% --- 37

Cool! Fun!!! ...Incomprehensible!

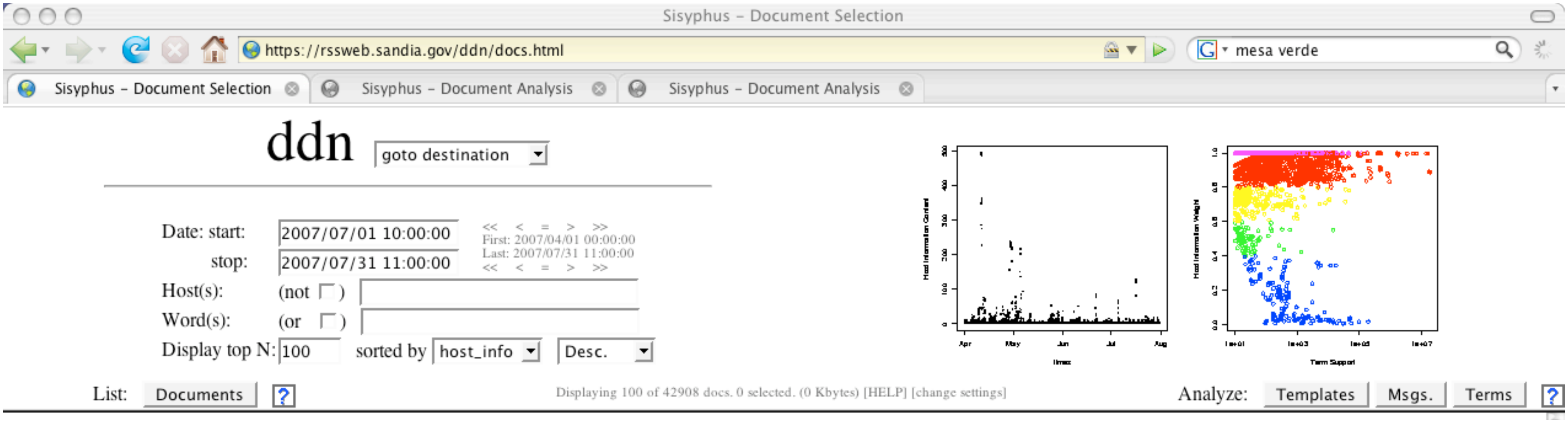
Finding Needles in a Craystack

1. Which files contain useful information?
2. Which words convey useful information?
3. Any patterns?

To be Useful,

It Must be Understandable

(to the sysadmins)



https://rssweb.sandia.gov/ddn/docs.html

mesa verde

ddn

Date: start: 2007/07/01 10:00:00

stop: 2007/07/31 11:00:00

First: 2007/04/01 00:00:00
Last: 2007/07/31 11:00:00

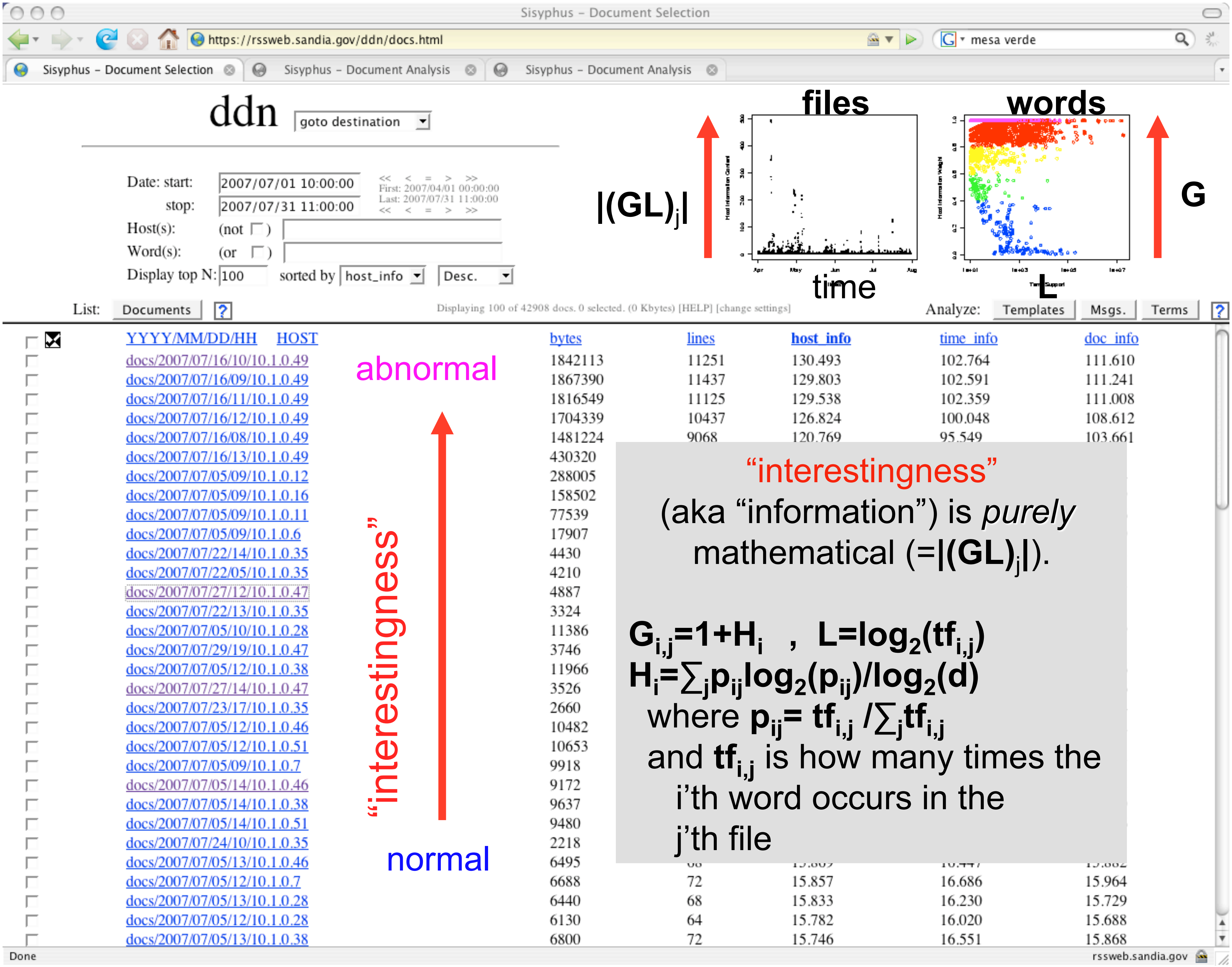
Host(s): (not □)

Word(s): (or □)

Display top N: 100 sorted by host_info Desc.

Displaying 100 of 42908 docs. 0 selected. (0 Kbytes) [HELP] [change settings]

1. Which files contain <u>useful</u> information?


Sisyphus – Document Selection
https://rssweb.sandia.gov/ddn/docs.html
mesa verde
Sisyphus – Document Selection
Sisyphus – Document Analysis
Sisyphus – Document Analysis
files
words
time
L
|(GL)_j|
G
Apr
May
Jun
Jul
Aug
Done
rssweb.sandia.gov

ddn goto destination ▾

Date: start: 2007/07/01 10:00:00 << < = > >> First: 2007/04/01 00:00:00

stop: 2007/07/31 11:00:00 Last: 2007/07/31 11:00:00 << < = > >>

Host(s): (not □)

Word(s): (or □)

Display top N: 100 sorted by host_info ▾ Desc. ▾

List: Documents ? Displaying 100 of 42908 docs. 0 selected. (0 Kbytes) [HELP] [change settings] Analyze: Templates Msgs. Terms ?

☒	YYYY/MM/DD/HH HOST	bytes	lines	host_info	time_info	doc_info
□	docs/2007/07/16/10/10.1.0.49	1842113	11251	130.493	102.764	111.610
□	docs/2007/07/16/09/10.1.0.49	1867390	11437	129.803	102.591	111.241
□	docs/2007/07/16/11/10.1.0.49	1816549	11125	129.538	102.359	111.008
□	docs/2007/07/16/12/10.1.0.49	1704339	10437	126.824	100.048	108.612
□	docs/2007/07/16/08/10.1.0.49	1481224	9068	120.769	95.549	103.661
□	docs/2007/07/16/13/10.1.0.49	430320				
□	docs/2007/07/05/09/10.1.0.12	288005				
□	docs/2007/07/05/09/10.1.0.16	158502				
□	docs/2007/07/05/09/10.1.0.11	77539				
□	docs/2007/07/05/09/10.1.0.6	17907				
□	docs/2007/07/22/14/10.1.0.35	4430				
□	docs/2007/07/22/05/10.1.0.35	4210				
□	docs/2007/07/27/12/10.1.0.47	4887				
□	docs/2007/07/22/13/10.1.0.35	3324				
□	docs/2007/07/05/10/10.1.0.28	11386				
□	docs/2007/07/29/19/10.1.0.47	3746				
□	docs/2007/07/05/12/10.1.0.38	11966				
□	docs/2007/07/27/14/10.1.0.47	3526				
□	docs/2007/07/23/17/10.1.0.35	2660				
□	docs/2007/07/05/12/10.1.0.46	10482				
□	docs/2007/07/05/12/10.1.0.51	10653				
□	docs/2007/07/05/09/10.1.0.7	9918				
□	docs/2007/07/05/14/10.1.0.46	9172				
□	docs/2007/07/05/14/10.1.0.38	9637				
□	docs/2007/07/05/14/10.1.0.51	9480				
□	docs/2007/07/24/10/10.1.0.35	2218				
□	docs/2007/07/05/13/10.1.0.46	6495	68	15.869	16.447	15.882
□	docs/2007/07/05/12/10.1.0.7	6688	72	15.857	16.686	15.964
□	docs/2007/07/05/13/10.1.0.28	6440	68	15.833	16.230	15.729
□	docs/2007/07/05/12/10.1.0.28	6130	64	15.782	16.020	15.688
□	docs/2007/07/05/13/10.1.0.38	6800	72	15.746	16.551	15.868

abnormal

"interestingness"

normal

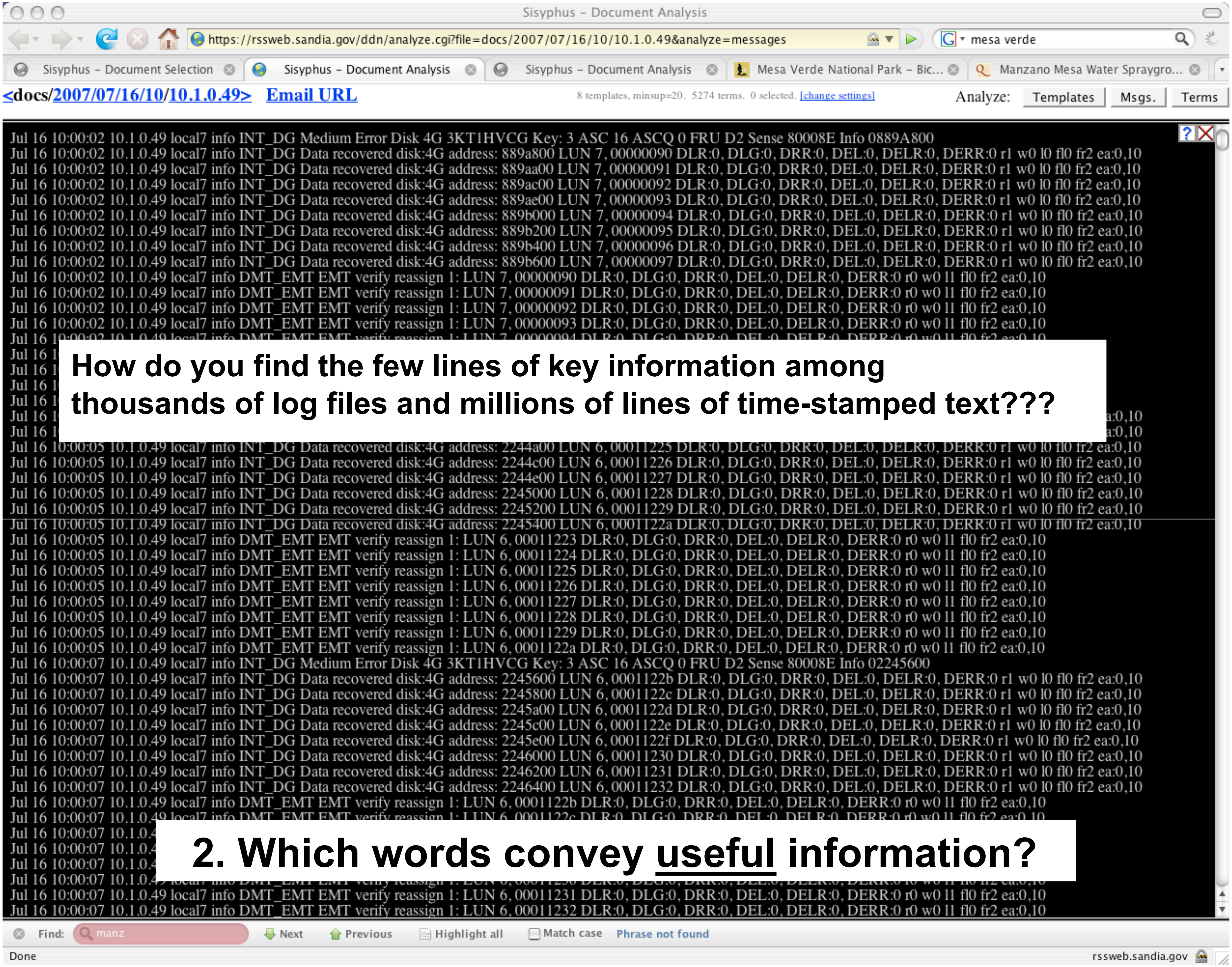
"interestingness" (aka "information") is *purely* mathematical (=$|(GL)_j|$).

$G_{i,j}=1+H_i$, $L=\log_2(tf_{i,j})$

$H_i=\sum_j p_{ij}\log_2(p_{ij})/\log_2(d)$

where $p_{ij}= tf_{i,j} /\sum_j tf_{i,j}$

and $tf_{i,j}$ is how many times the i'th word occurs in the j'th file


Sisyphus – Document Analysis
https://rssweb.sandia.gov/ddn/analyze.cgi?file=docs/2007/07/16/10/10.1.0.49&analyze=messages
mesa verde
Sisyphus – Document Selection
Sisyphus – Document Analysis
Sisyphus – Document Analysis
Mesa Verde National Park – Bic...
Manzano Mesa Water Spraygro...
<docs/2007/07/16/10/10.1.0.49>
Email URL
8 templates, minsup=20. 5274 terms. 0 selected. [change settings]
Analyze:
Templates
Msgs.
Terms
Find:
manz
Next
Previous
Highlight all
Match case
Phrase not found
Done
rssweb.sandia.gov

```
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Medium Error Disk 4G 3KT1HVCG Key: 3 ASC 16 ASCQ 0 FRU D2 Sense 80008E Info 0889A800
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889a800 LUN 7, 00000090 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889aa00 LUN 7, 00000091 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889ac00 LUN 7, 00000092 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889ae00 LUN 7, 00000093 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889b000 LUN 7, 00000094 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889b200 LUN 7, 00000095 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889b400 LUN 7, 00000096 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889b600 LUN 7, 00000097 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 7, 00000090 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 7, 00000091 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
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Jul 16 1                                                                                              a:0,10
Jul 16 1                                                                                              a:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2244a00 LUN 6, 00011225 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2244c00 LUN 6, 00011226 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2244e00 LUN 6, 00011227 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245000 LUN 6, 00011228 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245200 LUN 6, 00011229 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245400 LUN 6, 0001122a DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
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Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011224 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
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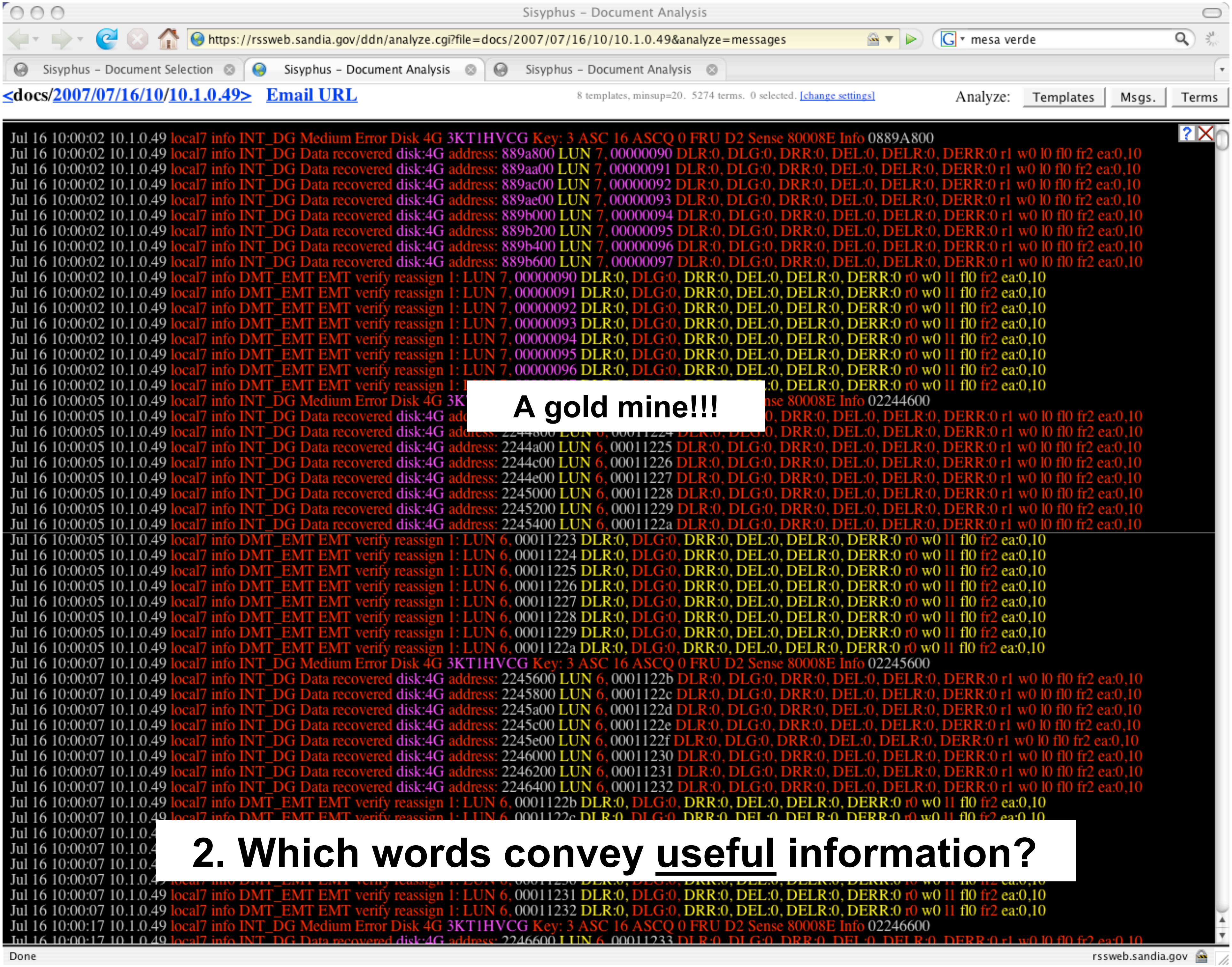
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011228 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011229 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 0001122a DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Medium Error Disk 4G 3KT1HVCG Key: 3 ASC 16 ASCQ 0 FRU D2 Sense 80008E Info 02245600
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245600 LUN 6, 0001122b DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245800 LUN 6, 0001122c DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245a00 LUN 6, 0001122d DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245c00 LUN 6, 0001122e DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245e00 LUN 6, 0001122f DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2246000 LUN 6, 00011230 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2246200 LUN 6, 00011231 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2246400 LUN 6, 00011232 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 0001122b DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 0001122c DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.4
Jul 16 10:00:07 10.1.0.4
Jul 16 10:00:07 10.1.0.4
Jul 16 10:00:07 10.1.0.4
Jul 16 10:00:07 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011231 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011232 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
```

How do you find the few lines of key information among thousands of log files and millions of lines of time-stamped text???

2. Which words convey useful information?


Sisyphus – Document Analysis
Sisyphus – Document Selection
Sisyphus – Document Analysis
Sisyphus – Document Analysis
Analyze:
Templates
Msgs.
Terms
Done
rssweb.sandia.gov

https://rssweb.sandia.gov/ddn/analyze.cgi?file=docs/2007/07/16/10/10.1.0.49&analyze=messages

mesa verde

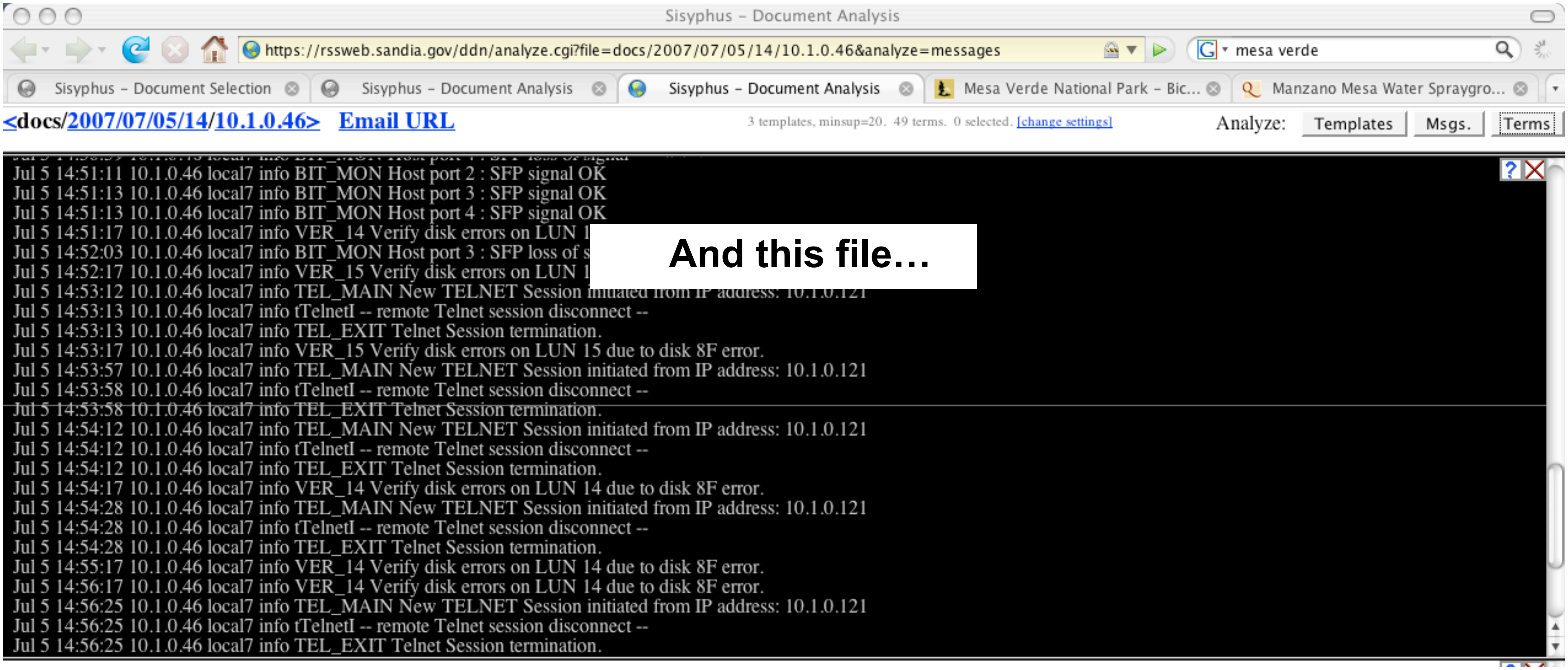
<docs/2007/07/16/10/10.1.0.49> Email URL

8 templates, minsup=20. 5274 terms. 0 selected. [change settings]

```
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Medium Error Disk 4G 3KT1HVCG Key: 3 ASC 16 ASCQ 0 FRU D2 Sense 80008E Info 0889A800
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889a800 LUN 7, 00000090 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889aa00 LUN 7, 00000091 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889ac00 LUN 7, 00000092 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889ae00 LUN 7, 00000093 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889b000 LUN 7, 00000094 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889b200 LUN 7, 00000095 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889b400 LUN 7, 00000096 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 889b600 LUN 7, 00000097 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 7, 00000090 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 7, 00000091 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 7, 00000092 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 7, 00000093 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 7, 00000094 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 7, 00000095 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 7, 00000096 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:02 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: L                           :0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Medium Error Disk 4G 3K                           nse 80008E Info 02244600
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G ad                          0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2244800 LUN 6, 00011224 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2244a00 LUN 6, 00011225 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2244c00 LUN 6, 00011226 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2244e00 LUN 6, 00011227 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245000 LUN 6, 00011228 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245200 LUN 6, 00011229 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245400 LUN 6, 0001122a DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011223 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011224 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011225 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011226 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011227 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011228 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011229 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:05 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 0001122a DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Medium Error Disk 4G 3KT1HVCG Key: 3 ASC 16 ASCQ 0 FRU D2 Sense 80008E Info 02245600
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245600 LUN 6, 0001122b DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245800 LUN 6, 0001122c DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245a00 LUN 6, 0001122d DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245c00 LUN 6, 0001122e DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2245e00 LUN 6, 0001122f DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2246000 LUN 6, 00011230 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2246200 LUN 6, 00011231 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2246400 LUN 6, 00011232 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 0001122b DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 0001122c DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.4
Jul 16 10:00:07 10.1.0.4
Jul 16 10:00:07 10.1.0.4
Jul 16 10:00:07 10.1.0.4
Jul 16 10:00:07 10.1.0.4
Jul 16 10:00:07 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011231 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:07 10.1.0.49 local7 info DMT_EMT EMT verify reassign 1: LUN 6, 00011232 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r0 w0 l1 fl0 fr2 ea:0,10
Jul 16 10:00:17 10.1.0.49 local7 info INT_DG Medium Error Disk 4G 3KT1HVCG Key: 3 ASC 16 ASCQ 0 FRU D2 Sense 80008E Info 02246600
Jul 16 10:00:17 10.1.0.49 local7 info INT_DG Data recovered disk:4G address: 2246600 LUN 6, 00011233 DLR:0, DLG:0, DRR:0, DEL:0, DELR:0, DERR:0 r1 w0 l0 fl0 fr2 ea:0,10
```

A gold mine!!!

2. Which words convey useful information?


Sisyphus – Document Analysis
mesa verde
Sisyphus – Document Selection
Sisyphus – Document Analysis
Sisyphus – Document Analysis
Mesa Verde National Park – Bic...
Manzano Mesa Water Spraygro...
Analyze:
Templates
Msgs.
Terms

https://rssweb.sandia.gov/ddn/analyze.cgi?file=docs/2007/07/05/14/10.1.0.46&analyze=messages

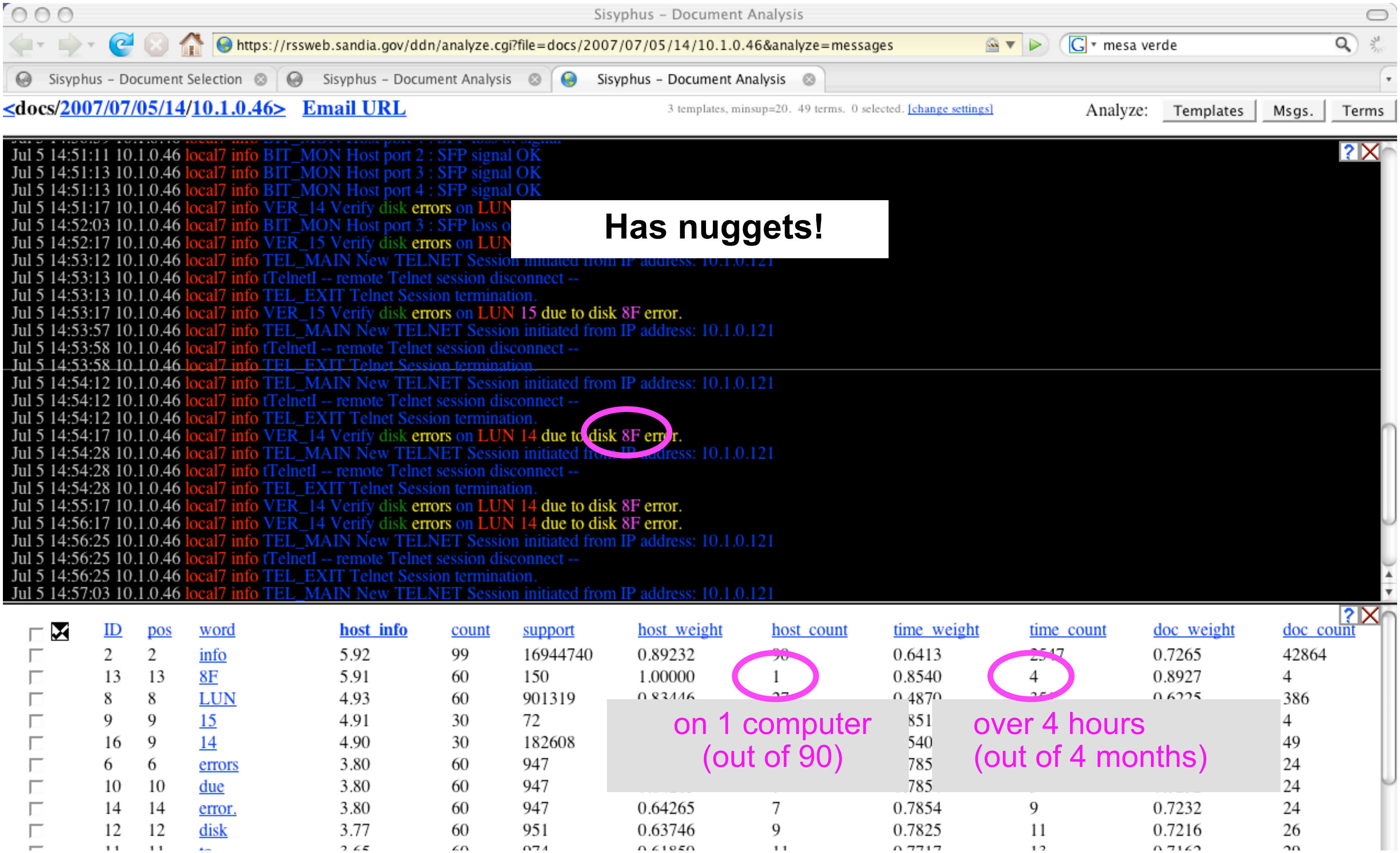
<docs/2007/07/05/14/10.1.0.46> Email URL

3 templates, minsup=20. 49 terms. 0 selected. [change settings]

```
Jul 5 14:51:11 10.1.0.46 local7 info BIT_MON Host port 2 : SFP signal OK
Jul 5 14:51:13 10.1.0.46 local7 info BIT_MON Host port 3 : SFP signal OK
Jul 5 14:51:13 10.1.0.46 local7 info BIT_MON Host port 4 : SFP signal OK
Jul 5 14:51:17 10.1.0.46 local7 info VER_14 Verify disk errors on LUN 1
Jul 5 14:52:03 10.1.0.46 local7 info BIT_MON Host port 3 : SFP loss of s
Jul 5 14:52:17 10.1.0.46 local7 info VER_15 Verify disk errors on LUN 1
Jul 5 14:53:12 10.1.0.46 local7 info TEL_MAIN New TELNET Session initiated from IP address: 10.1.0.121
Jul 5 14:53:13 10.1.0.46 local7 info tTelnetI -- remote Telnet session disconnect --
Jul 5 14:53:13 10.1.0.46 local7 info TEL_EXIT Telnet Session termination.
Jul 5 14:53:17 10.1.0.46 local7 info VER_15 Verify disk errors on LUN 15 due to disk 8F error.
Jul 5 14:53:57 10.1.0.46 local7 info TEL_MAIN New TELNET Session initiated from IP address: 10.1.0.121
Jul 5 14:53:58 10.1.0.46 local7 info tTelnetI -- remote Telnet session disconnect --
Jul 5 14:53:58 10.1.0.46 local7 info TEL_EXIT Telnet Session termination.
Jul 5 14:54:12 10.1.0.46 local7 info TEL_MAIN New TELNET Session initiated from IP address: 10.1.0.121
Jul 5 14:54:12 10.1.0.46 local7 info tTelnetI -- remote Telnet session disconnect --
Jul 5 14:54:12 10.1.0.46 local7 info TEL_EXIT Telnet Session termination.
Jul 5 14:54:17 10.1.0.46 local7 info VER_14 Verify disk errors on LUN 14 due to disk 8F error.
Jul 5 14:54:28 10.1.0.46 local7 info TEL_MAIN New TELNET Session initiated from IP address: 10.1.0.121
Jul 5 14:54:28 10.1.0.46 local7 info tTelnetI -- remote Telnet session disconnect --
Jul 5 14:54:28 10.1.0.46 local7 info TEL_EXIT Telnet Session termination.
Jul 5 14:55:17 10.1.0.46 local7 info VER_14 Verify disk errors on LUN 14 due to disk 8F error.
Jul 5 14:56:17 10.1.0.46 local7 info VER_14 Verify disk errors on LUN 14 due to disk 8F error.
Jul 5 14:56:25 10.1.0.46 local7 info TEL_MAIN New TELNET Session initiated from IP address: 10.1.0.121
Jul 5 14:56:25 10.1.0.46 local7 info tTelnetI -- remote Telnet session disconnect --
Jul 5 14:56:25 10.1.0.46 local7 info TEL_EXIT Telnet Session termination.
```

And this file…

2. Which words convey useful information?



Sisyphus – Document Analysis
https://rssweb.sandia.gov/ddn/analyze.cgi?file=docs/2007/07/05/14/10.1.0.46&analyze=messages
mesa verde
Sisyphus – Document Selection
Sisyphus – Document Analysis
Sisyphus – Document Analysis
<docs/2007/07/05/14/10.1.0.46>
Email URL
3 templates, minsup=20. 49 terms. 0 selected. [change settings]
Analyze:
Templates
Msgs.
Terms

```
Jul 5 14:51:11 10.1.0.46 local7 info BIT_MON Host port 2 : SFP signal OK
Jul 5 14:51:13 10.1.0.46 local7 info BIT_MON Host port 3 : SFP signal OK
Jul 5 14:51:13 10.1.0.46 local7 info BIT_MON Host port 4 : SFP signal OK
Jul 5 14:51:17 10.1.0.46 local7 info VER_14 Verify disk errors on LUN
Jul 5 14:52:03 10.1.0.46 local7 info BIT_MON Host port 3 : SFP loss o
Jul 5 14:52:17 10.1.0.46 local7 info VER_15 Verify disk errors on LUN
Jul 5 14:53:12 10.1.0.46 local7 info TEL_MAIN New TELNET Session
Jul 5 14:53:13 10.1.0.46 local7 info tTelnetI -- remote Telnet session disconnect --
Jul 5 14:53:13 10.1.0.46 local7 info TEL_EXIT Telnet Session termination.
Jul 5 14:53:17 10.1.0.46 local7 info VER_15 Verify disk errors on LUN 15 due to disk 8F error.
Jul 5 14:53:57 10.1.0.46 local7 info TEL_MAIN New TELNET Session initiated from IP address: 10.1.0.121
Jul 5 14:53:58 10.1.0.46 local7 info tTelnetI -- remote Telnet session disconnect --
Jul 5 14:53:58 10.1.0.46 local7 info TEL_EXIT Telnet Session termination.
Jul 5 14:54:12 10.1.0.46 local7 info TEL_MAIN New TELNET Session initiated from IP address: 10.1.0.121
Jul 5 14:54:12 10.1.0.46 local7 info tTelnetI -- remote Telnet session disconnect --
Jul 5 14:54:12 10.1.0.46 local7 info TEL_EXIT Telnet Session termination.
Jul 5 14:54:17 10.1.0.46 local7 info VER_14 Verify disk errors on LUN 14 due to disk 8F error.
Jul 5 14:54:28 10.1.0.46 local7 info TEL_MAIN New TELNET Session initiated from IP address: 10.1.0.121
Jul 5 14:54:28 10.1.0.46 local7 info tTelnetI -- remote Telnet session disconnect --
Jul 5 14:54:28 10.1.0.46 local7 info TEL_EXIT Telnet Session termination.
Jul 5 14:55:17 10.1.0.46 local7 info VER_14 Verify disk errors on LUN 14 due to disk 8F error.
Jul 5 14:56:17 10.1.0.46 local7 info VER_14 Verify disk errors on LUN 14 due to disk 8F error.
Jul 5 14:56:25 10.1.0.46 local7 info TEL_MAIN New TELNET Session initiated from IP address: 10.1.0.121
Jul 5 14:56:25 10.1.0.46 local7 info tTelnetI -- remote Telnet session disconnect --
Jul 5 14:56:25 10.1.0.46 local7 info TEL_EXIT Telnet Session termination.
Jul 5 14:57:03 10.1.0.46 local7 info TEL_MAIN New TELNET Session initiated from IP address: 10.1.0.121
```

Has nuggets!

☐	☒	ID	pos	word	host_info	count	support	host_weight	host_count	time_weight	time_count	doc_weight	doc_count
☐		2	2	info	5.92	99	16944740	0.89232	90	0.6413	2547	0.7265	42864
☐		13	13	8F	5.91	60	150	1.00000	1	0.8540	4	0.8927	4
☐		8	8	LUN	4.93	60	901319	0.83446	27	0.4870	[illegible]	0.6225	386
☐		9	9	15	4.91	30	72	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
☐		16	9	14	4.90	30	182608	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49
☐		6	6	errors	3.80	60	947	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24
☐		10	10	due	3.80	60	947	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24
☐		14	14	error.	3.80	60	947	0.64265	7	0.7854	9	0.7232	24
☐		12	12	disk	3.77	60	951	0.63746	9	0.7825	11	0.7216	26
☐		11	11	to	3.65	60	974	0.61850	11	0.7717	13	0.7162	29

on 1 computer
(out of 90)

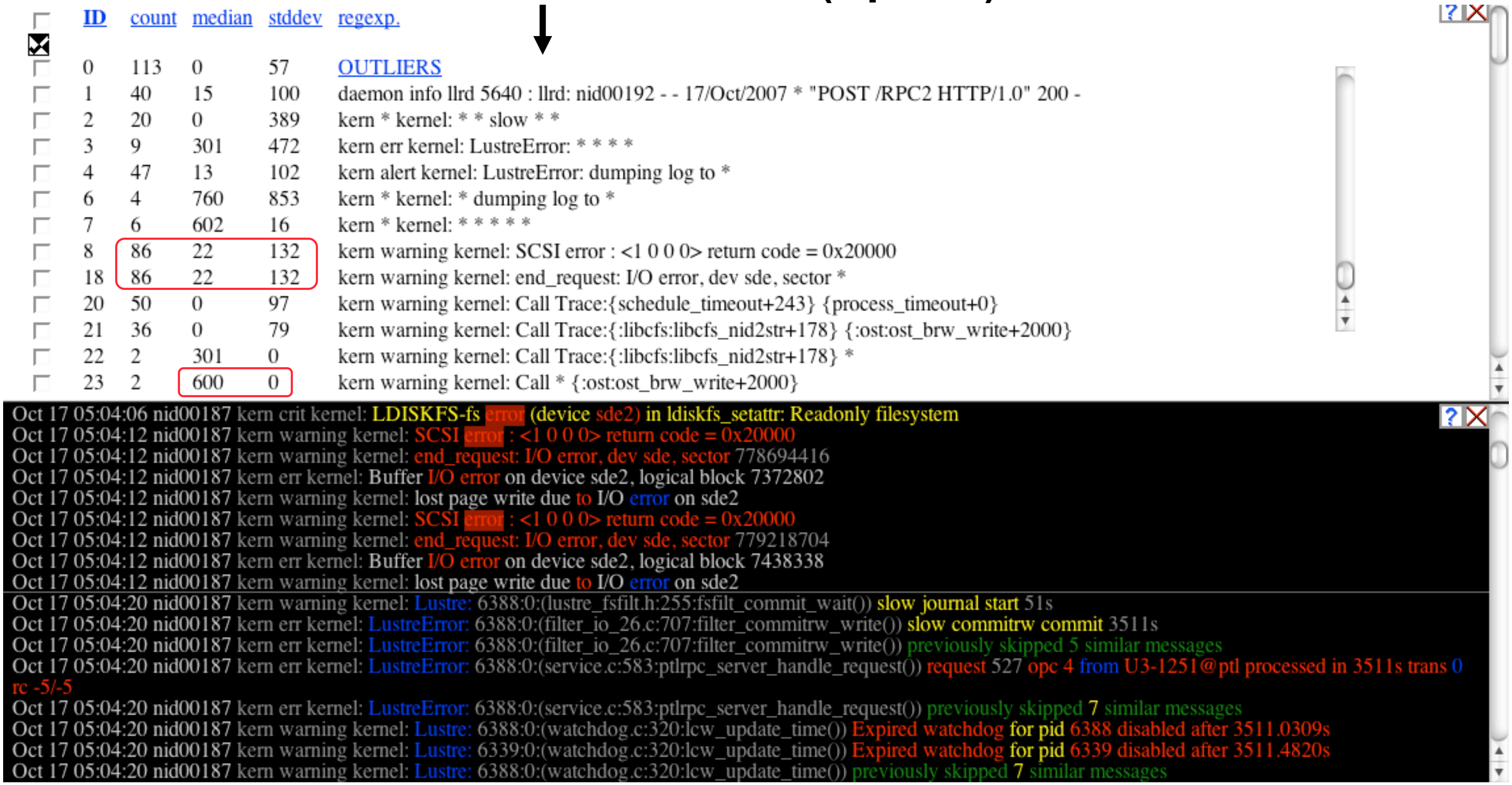
over 4 hours
(out of 4 months)

2. Which words convey useful information?

3. Are there any patterns?

Time patterns.

Linewise word patterns via sequencing (Teiresias), clustering (SLCT), and association (Apriori).



☐	ID	count	median	stddev	regexp.
☒					
☐	0	113	0	57	OUTLIERS
☐	1	40	15	100	daemon info llrd 5640 : llrd: nid00192 - - 17/Oct/2007 * "POST /RPC2 HTTP/1.0" 200 -
☐	2	20	0	389	kern * kernel: * * slow * *
☐	3	9	301	472	kern err kernel: LustreError: * * * *
☐	4	47	13	102	kern alert kernel: LustreError: dumping log to *
☐	6	4	760	853	kern * kernel: * dumping log to *
☐	7	6	602	16	kern * kernel: * * * * *
☐	8	86	22	132	kern warning kernel: SCSI error : <1 0 0 0> return code = 0x20000
☐	18	86	22	132	kern warning kernel: end_request: I/O error, dev sde, sector *
☐	20	50	0	97	kern warning kernel: Call Trace:{schedule_timeout+243} {process_timeout+0}
☐	21	36	0	79	kern warning kernel: Call Trace:{:libcfs:libcfs_nid2str+178} {:ost:ost_brw_write+2000}
☐	22	2	301	0	kern warning kernel: Call Trace:{:libcfs:libcfs_nid2str+178} *
☐	23	2	600	0	kern warning kernel: Call * {:ost:ost_brw_write+2000}

```
Oct 17 05:04:06 nid00187 kern crit kernel: LDISKFS-fs error (device sde2) in ldiskfs_setattr: Readonly filesystem
Oct 17 05:04:12 nid00187 kern warning kernel: SCSI error : <1 0 0 0> return code = 0x20000
Oct 17 05:04:12 nid00187 kern warning kernel: end_request: I/O error, dev sde, sector 778694416
Oct 17 05:04:12 nid00187 kern err kernel: Buffer I/O error on device sde2, logical block 7372802
Oct 17 05:04:12 nid00187 kern warning kernel: lost page write due to I/O error on sde2
Oct 17 05:04:12 nid00187 kern warning kernel: SCSI error : <1 0 0 0> return code = 0x20000
Oct 17 05:04:12 nid00187 kern warning kernel: end_request: I/O error, dev sde, sector 779218704
Oct 17 05:04:12 nid00187 kern err kernel: Buffer I/O error on device sde2, logical block 7438338
Oct 17 05:04:12 nid00187 kern warning kernel: lost page write due to I/O error on sde2
Oct 17 05:04:20 nid00187 kern warning kernel: Lustre: 6388:0:(lustre_fsfilt.h:255:fsfilt_commit_wait()) slow journal start 51s
Oct 17 05:04:20 nid00187 kern err kernel: LustreError: 6388:0:(filter_io_26.c:707:filter_commitrw_write()) slow commitrw commit 3511s
Oct 17 05:04:20 nid00187 kern err kernel: LustreError: 6388:0:(filter_io_26.c:707:filter_commitrw_write()) previously skipped 5 similar messages
Oct 17 05:04:20 nid00187 kern err kernel: LustreError: 6388:0:(service.c:583:ptlrpc_server_handle_request()) request 527 opc 4 from U3-1251@ptl processed in 3511s trans 0
rc -5/-5
Oct 17 05:04:20 nid00187 kern err kernel: LustreError: 6388:0:(service.c:583:ptlrpc_server_handle_request()) previously skipped 7 similar messages
Oct 17 05:04:20 nid00187 kern warning kernel: Lustre: 6388:0:(watchdog.c:320:lcw_update_time()) Expired watchdog for pid 6388 disabled after 3511.0309s
Oct 17 05:04:20 nid00187 kern warning kernel: Lustre: 6339:0:(watchdog.c:320:lcw_update_time()) Expired watchdog for pid 6339 disabled after 3511.4820s
Oct 17 05:04:20 nid00187 kern warning kernel: Lustre: 6388:0:(watchdog.c:320:lcw_update_time()) previously skipped 7 similar messages
```

Production Impacts

Sisyphus has found a wide range of problems:

Failures:

- Disks and controllers
- Network interfaces
- Power supplies
- Memory

Misconfigurations:

- Performance-decreasing BIOS setting
- Overhead-increasing RAID controller setting
- Inconsistent software versions across nodes
- Faulty software configuration

Problematic user behavior:

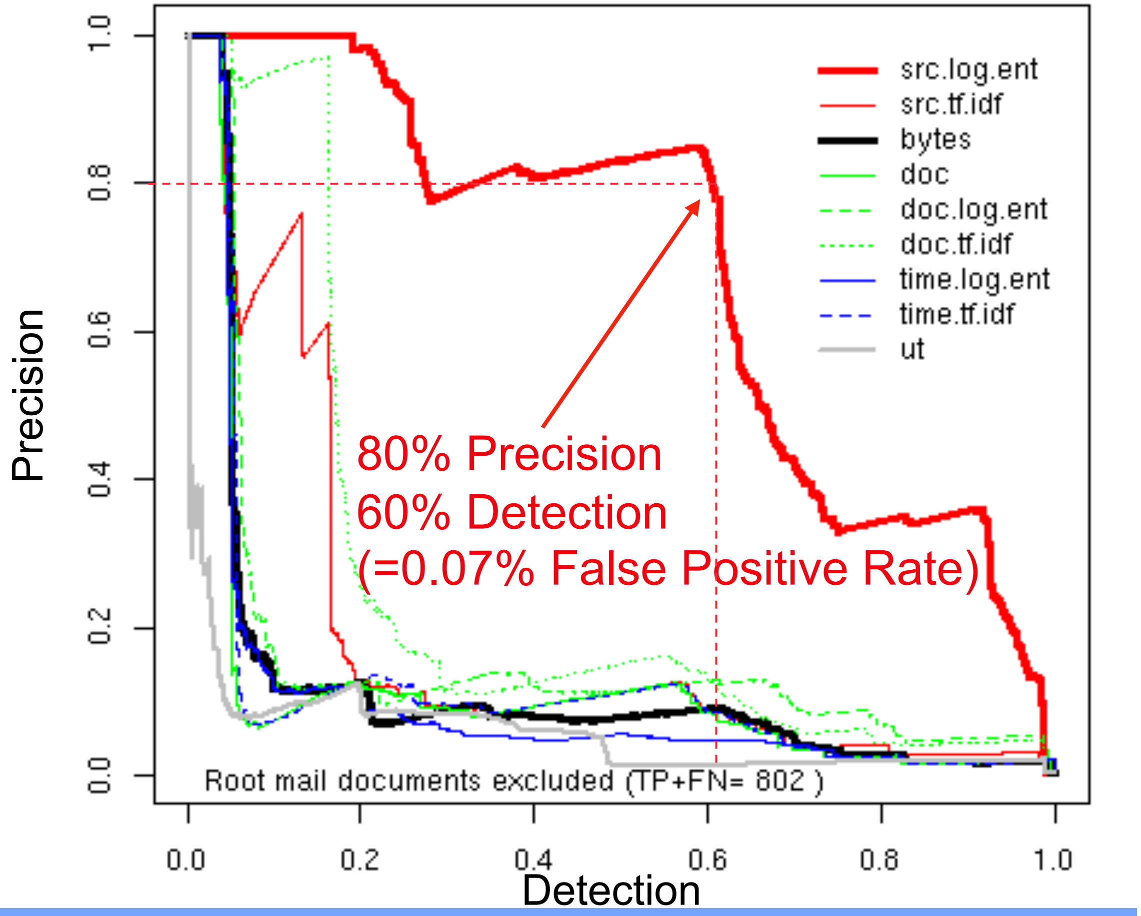
- Unbalanced disk RAID stripe usage
- Inappropriate remote monitoring

Which has enabled focused reactive and proactive responses.

See http://www.cs.sandia.gov/sisyphus for more info.

“Establish Quantitative Measurement of Effectiveness”

33 Unsupervised Classifiers Tested!



80% Precision
60% Detection
(=0.07% False Positive Rate)

NWCC/Spirit Data
512 Nodes, 23 Days
8.3M log messages
36K terms, 243K docs
3.9K emails!
P=62 ; 802   N=243K

		True Class: *P*	*N*
Alarm Class:	P	TP	FP
	N	FN	TN

TP=True Positives
FP=False Positives
FN=False Negatives
TN=True Negatives

Metrics:

Alarm Precision = TP/(TP+FP)
Event Detection = TP/(TP+FN)

RAS Metrics

RAS = Reliability, Availability, Serviceability

Good science is measurable!

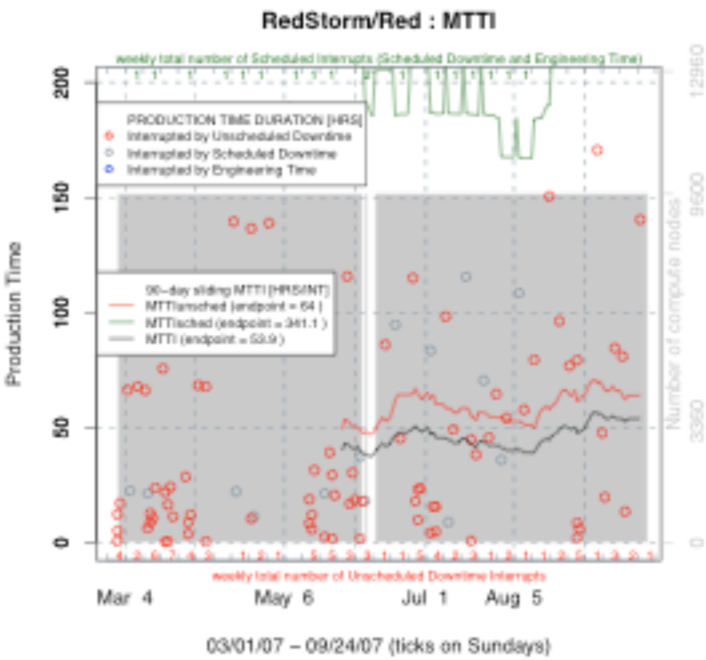
But…

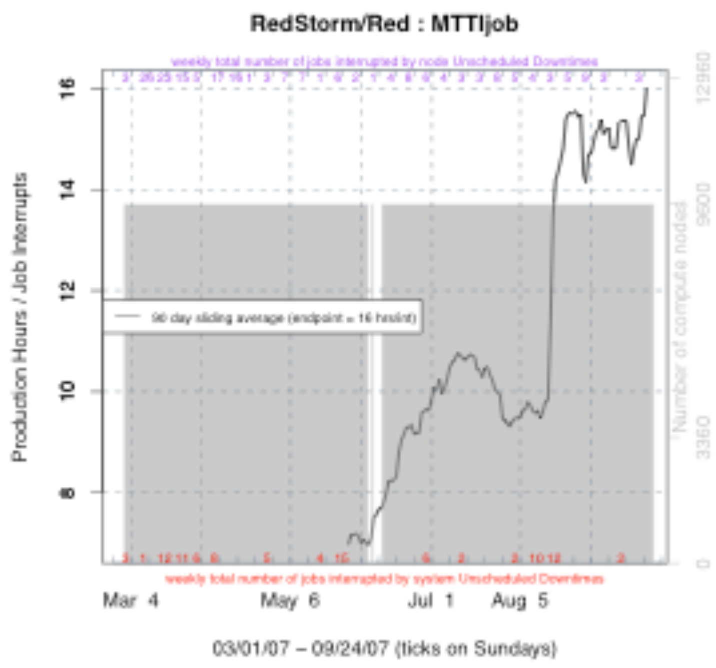
NO STANDARD is currently used for measuring supercomputer RAS!!!

RAS Metrics: Challenges

Difficult to agree on:

- **How to define failure (or interrupt).**
- **How to measure reliability.**
- **The need and method to change the processes and procedures involved.**





RAS Metrics: Plans

The Tri-laboratory Linux Compute Cluster presents a fantastic RAS metrics opportunity:

- Same vendor
- Same hardware
- Same system software

Our FY08 goal is to produce a specification and reference implementation for TLCC RAS metrics.

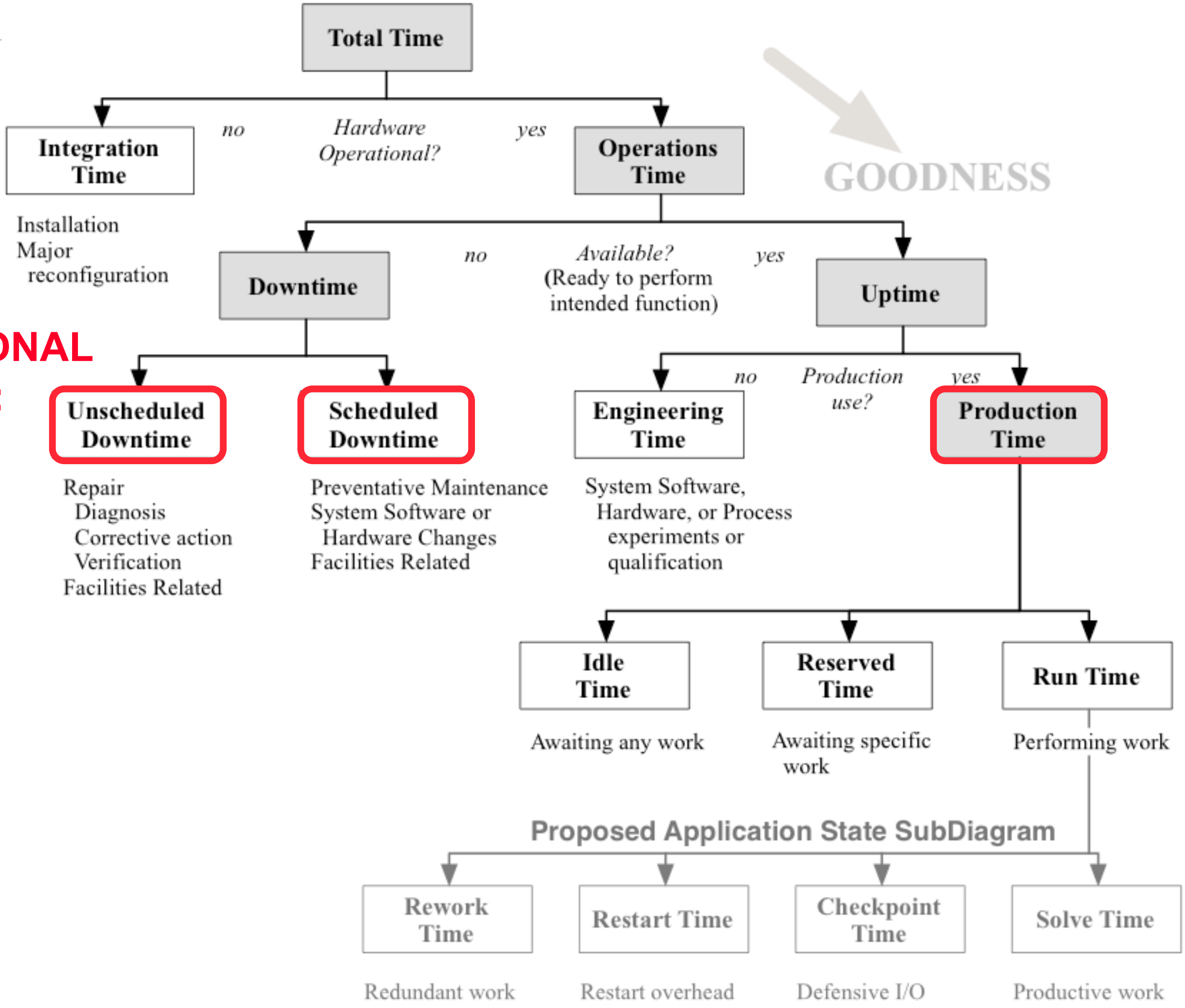
Key Idea:

track OPERATIONAL CONTEXT
for every node, at all times

Tri-lab-developed Component State Diagram *(Based on SEMI-E10)*

Each component is in exactly one non-grey state at all times.

OPERATIONAL CONTEXT:



Total Time

Hardware Operational? *no* / *yes*

Integration Time

Installation
Major
reconfiguration

Operations Time

GOODNESS

Available? (Ready to perform intended function) *no* / *yes*

Downtime

Unscheduled Downtime

Repair
Diagnosis
Corrective action
Verification
Facilities Related

Scheduled Downtime

Preventative Maintenance
System Software or
Hardware Changes
Facilities Related

Uptime

Production use? *no* / *yes*

Engineering Time

System Software,
Hardware, or Process
experiments or
qualification

Production Time

Idle Time

Awaiting any work

Reserved Time

Awaiting specific work

Run Time

Performing work

Proposed Application State SubDiagram

Rework Time

Redundant work

Restart Time

Restart overhead

Checkpoint Time

Defensive I/O

Solve Time

Productive work

Summary

Supercomputer RAS is a rich research area.

Sandia is making significant contributions.

Applications, Operating systems, I/O systems, System architectures, Device control, Networking, Metrics, and Detection and prediction on logs and real-valued data.

(I have given you only a taste)

Standard RAS metrics are essential.

For improved RAS research, engineering, and operation.